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THE DEEP-SEA ZEOMORPH FISHES OF THE FAMILY GRAMMICOLEPIDAE

By GEORGE S. MYERS

Stanford University, California

THE RARITY of the strange oceanic fishes of the family Grammicolepidae, together with the unique character of their vertically attenuated scales, has placed them among the greatest desiderata of ichthyological collections. The four nominal species have been referred to three genera, but no previous writer appears to have examined more than one of them. Moreover, the type and supposedly the only known specimen of the first-discovered species seems to be lost, and Poey's original description of it has been misinterpreted.

It is therefore of interest to find a fine specimen of Poey's species in the collections brought back by the Johnson-Smithsonian deep-sea expedition, as well as three examples of *Xenolepidichthys dalgleishi*, a species hitherto known only from South Africa, among the fishes collected by the U. S. S. *Albatross* in the Philippines. Prof. Albert E. Parr has been kind enough to allow me to examine Mowbray's types of *Grammicolepis squamilineatus* in the Bingham Oceanographic Collection at Yale University and to bring two of the paratypes to Washington for comparison. Finally, I have had at hand Jordan's type of *Vesposus egregius*, from Hawaii.

This material is more varied than that examined by other writers, and it has enabled me to determine that the known specimens of the

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family belong to only two species, each of which appears to have a world-wide distribution in the depths of tropical and semitropical seas.[1]

Unfortunately, the rarity of the material in my hands and the necessary apportionment of the Philippine *Albatross* fishes to three institutions have not permitted the desired osteological re-investigation of the family. It is to be hoped that future specimens will allow of this.

Family GRAMMICOLEPIDAE

Grammicolepidi POEY, 1873, p. 405 (description).

Grammicolepididae GILL, *in* Kingsley, 1885, p. 207 (name only).—GILL, 1893, p. 134 (name only).—GOODE and BEAN, 1895, p. 218 (description).—JORDAN and EVERMANN, 1896, p. 973 (description).

Grammicolepidae SHUFELDT, 1888, p. 274 (translation of Poey's paper).—JORDAN, 1905, vol. 2, p. 249 (brief mention); 1923, p. 171 (name and included genera).—BARNARD, 1925, p. 370 (description).

Zeidae (part) BOULENGER, 1902, p. 300 (critical remarks).—REGAN, 1910, p. 483 (critical remarks).—WEBER, 1913, p. 409 (remarks).

The true relationship of the family Grammicolepidae was not appreciated at first. Poey asserted that *Grammicolepis* was related to the Berycidae and the Carangidae. Shufeldt agreed with Poey in relating the fish to the carangids, but he noted many important differences in the skeleton. In 1885 Gill placed the grammicolepids, along with *Lampris*, *Luvarus*, *Mene*, *Kurtus*, *Capros*, and *Zeus*, as a distant ally of the Scombroidea. His inclusion of the Caproidae and Zeidae in this category does not seem to imply that he had any distinct understanding of their closeness to *Grammicolepis*. In 1893 Gill placed the Grammicolepidae, together with most of the fishes mentioned above, in his group Scombroidea, but he stated that this assemblage was not a natural group and would doubtless be split up after further study. Goode and Bean and Jordan and Evermann merely left *Grammicolepis* where Gill placed it.

Boulenger appears to have been the first to recognize the really close similarity of *Grammicolepis* to the Zeidae, and he placed it in that family. Regan similarly placed it in the Zeidae, mentioning particularly its resemblance to the genera *Cyttus* and *Neocyttus* in the presence of the basisphenoid and in the prominence of the supraoccipitals.

The genera that are now usually referred to the Zeidae, although few in number, seem to me to be considerably divergent in many de-

[1] J. L. B. Smith (1931, p. 145, 2 figs.) has recently described a supposed new genus and species of South African grammicolepids as *Prionolepis hewitti*. I am indebted to Dr. Smith for the information that he now considers this fish to be a juvenile acanthurid.

tails, and I am inclined to think that there may be more than one family type among them. *Neocyttus* and *Cyttomimus* are certainly greatly different from *Zeus*, *Zen*, *Zenopsis*, and *Cyttus*. The grammicolepids are not particularly close to either of these groups in form and a number of minor details, and their scales are so vastly different that, for the present at least, I do not hesitate to give them family recognition. The final word as to their exact place must await a much-needed systematic and osteological investigation of all the zeomorph fishes.

The Grammicolepidae may, then, be defined as Zeomorphi (see Regan, 1910) in which (1) the scales are vertically linear in form, (2) the mouth is small and nearly vertical, (3) the maxillary is extremely short, (4) the anterior trunk muscles just reach the posterior edge of the frontals, (5) the occipital crest is thin, (6) the gills are 3½, with no slit behind the last, (7) the branchiostegals are 7 in number, (8) the caudal fin is composed of 13 branched rays with one main and several supplementary unbranched rays both above and below, and (9) the pelvic fins are I, 6.

Gill arches thin, with one thin double row of hemibranchs. The interior, or concave side, of each arch is smooth. Both the anterior and posterior faces of each arch except the last possess a series of low cross ridges, horizontal, or rather perpendicular, to the main line of the arch. These short ridges are studded with spines. On the posterior side of the inner (concave) ramus of the first arch there is a row of small papilliform projections that might be construed as gill rakers. At the upper end of each arch, where it curves around forward, the hemibranchs leave the arch proper and run up on the wall of the gill chamber. The gill structure in the two genera is identical, but it cannot be properly seen without excising a complete arch from a specimen. There is no slit behind the last gill.

Pseudobranchiae of large size are present at the upper end of the outer wall of the gill chamber. In some specimens the filaments are entwined with those of the first gill arch, but they may be separated by a little manipulation. I believe that either this or injury in probing accounts for Barnard's statement that *Xenolepidichthys* lacks pseudobranchiae. All four examples of this genus before me have them.

Branchiostegal rays 7 in number, the first three attached to the anterior limb and the last four attached to the posterior limb of the ceratohyal, as in *Zeus*. Poey, in speaking of *Grammicolepis*, says, "no he podido descubrir más que cuatro radios branquióstegos, sin poder asegurar que no haya mayor número." Evidently he thought there might be more than four; his skeleton of the type

seems to have been in an incomplete condition, from Shufeldt's remarks. Shufeldt did not mention the branchiostegals; they were probably entirely gone when he received the specimen. Barnard gave four branchiostegals for *Xenolepidichthys*. I myself thought this was correct until I dissected the muscle overlying the first three.

The frontal and nasal bones are prominent and are covered with rows of fine blunt spines. The preorbital is prominent and its outer face is rough with the spine-studded fluting of what appear to be mucous channels. Cheeks, opercle, subopercle, and, in *Grammicolepis*, the interopercle, scaled. Vertical and lower limbs of preopercle rough with fine granules. On the upper corners of the cheeks (in the postorbital region) and opercles, along the predorsal line, at the pectoral base, and on the caudal peduncle, the rough linear scales approach the proportions of normal scales.

A row of thin, bony bucklers, each bearing a main spine (and, anteriorly at least, one or more smaller, supplementary spines) extends along each side of the entire base of the dorsal and anal fins.

Eyes large, much greater than interorbital. Body deep and strongly compressed. Caudal peduncle slender. Pectoral fins small. Anal spines 2, separated by an interspace from the first soft ray. Soft dorsal and anal rays unbranched. Greatest body depth at origin of dorsal fin.

Teeth small, acicular, weak, in a single series on each jaw.

Besides a 43 mm specimen of *Xenolepidichthys* (see Smith, 1935), which retains some postlarval characters, no larvae or postlarvae of Grammicolepidae are known. The "*Acronurus*" larvae of the Acanthuridae, with their vertically elongate scales (see Lütken, 1880, pl. 5, figs. 4, 5), are likely to be mistaken for young grammicolepids. One young acanthurid, with a most remarkable type of scales, has already been described as a grammicolepid (Smith, 1931, p. 146). These young acanthurids may be distinguished from the Grammicolepidae both by their different mouth structure and by their metallic "corselet" extending downward and forward from the pectoral base.

I experienced some difficulty at first in discovering valid characters to distinguish the two recognizable forms of Grammicolepidae. The external differences are mostly of a type unlike those that have been used in related groups, and I present them here in the form of a comparative table.

GRAMMICOLEPIS	XENOLEPIDICHTHYS
1. Scaly part of gular membrane not covering the blunt lower angle of the hyoid apparatus (urohyal), which is protected only by thin skin.	1. Scaly part of gular membrane nearly or quite covering the blunt lower angle of the hyoid apparatus (urohyal), which is protected not only by the scaly membrane but also by a thick layer of muscle under the latter.
2. All 7 of the branchiostegal rays lacking a cover of muscle and easily seen without dissection.	2. The first 3 of the 7 branchiostegal rays thickly covered by a sheet of muscle running to the lower posterior limb of the ceratohyal, and not visible without dissection of this muscle.
3. Upper anterior angle of the preventral profile (covering the anterior horn of the cleithrum), at gill slit, directly below the middle or anterior border of the pupil of the eye.	3. Upper anterior angle of the preventral profile (covering the anterior horn of the cleithrum), at gill slit, anterior to the vertical of the front border of the orbit.
4. First anal spine shorter than eye in half grown and adult.	4. First anal spine nearly equal to or exceeding length of head at all ages.
5. Tip of lower jaw, with mouth closed, opposite upper border of pupil.	5. Tip of lower jaw, with mouth closed, opposite middle or lower border of pupil.
6. Upper border of head above eye (at junction with scales of nape) sloping downward sharply behind.	6. Upper border of head above eye (at junction with scales of nape) sloping downward only slightly.
7. Interopercle plainly visible beneath lower limb of preopercle; scaled.	7. Interopercle mostly hidden under preopercle.
8. Body deep when young (depth almost equal to length minus caudal peduncle in a 75 mm specimen), growing more elongate with age.	8. Body very deep at all ages, the depth nearly equal to or greater than the length minus caudal peduncle.
9. Anterior portion of lateral line in a high, peaked curve in half grown, flattening out into an irregular, low curve with age.	9. Anterior portion of lateral line in a high, peaked curve at all ages.
10. Ends of dorsal and anal bases almost opposite in half grown, the end of the dorsal becoming decidedly more anterior with age.	10. Ends of dorsal and anal bases practically opposite at all ages.
11. Anterior part of nape concave (possibly becoming straight or convex in old age).	11. Anterior part of nape flat or convex at all ages.

Genus GRAMMICOLEPIS Poey

Grammicolepis Poey, 1873, p. 403 (type by monotypy, *G. brachiusculus* Poey).
Vesposus Jordan, 1921, p. 649 (type by original designation, *V. egregius* Jordan).

The generic characters are given in the table above. Only one species is known, from deep water about the West Indies, in the Caribbean, and off Hawaii.

GRAMMICOLEPIS BRACHIUSCULUS Poey

Grammicolepis brachiusculus Poey, 1873, p. 403, pl. 12 (near Habana, Cuba).—Shufeldt, 1888, p. 271, figs. 1–14 (on Poey's type specimen).—Goode and Bean, 1895, p. 218, pl. 61, fig. 221 (copy of Shufeldt's description and figure).—Jordan and Evermann, 1896, vol. 1, p. 974 (compiled).—Fowler, 1928, p. 96 (on Jordan's type of *Vesposus egregius*).

Vesposus egregius Jordan, 1921, p. 650, fig. 5 (deep water off Hawaii).—Jordan and Jordan, 1922, p. 24, fig. 1 (on Jordan's type specimen).

Grammicolepis squamilineatus (in part) Mowbray, *in* Breder, 1927, p. 30, fig. 14 (holotype and two paratypes; deep water north of Glover Reef, British Honduras).

U.S.N.M. no. 84098, a dried and distorted specimen approximately 230 mm in standard length (to end of hypural fan); killed by lava flowing from Mauna Loa into the sea off Alika, Island of Hawaii, in November 1919, and collected by Tom Reinhardt. Holotype of *Vesposus egregius* Jordan.

U.S.N.M. no 102129 (field no. 111), a specimen 182 mm in standard length; Johnson-Smithsonian deep-sea expedition station 23, off Punta Cerro Gordo, north coast of Puerto Rico, latitude 18°32′15″ N., longitude 66°17′45″ W., to latitude 18°32′00″ N., longitude 66°-21′15″ W.; February 4, 1933; otter trawl; 260 to 360 fathoms; S. Y. *Caroline*.

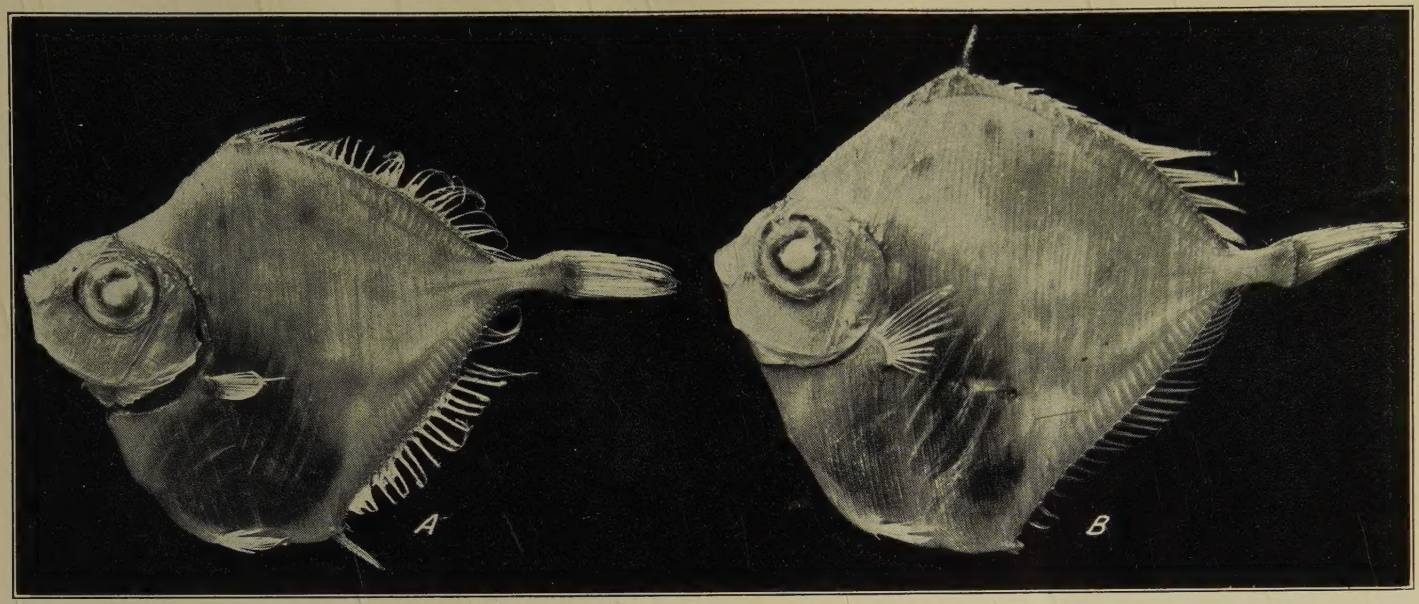
B. O. C. no. 517, a specimen 82 mm in standard length; deep water north of Glover Reef, off the coast of British Honduras; April 1925; S. Y. *Pawnee*. Holotype of *Grammicolepis squamilineatus* Mowbray.

B. O. C. no. 524, a specimen 85 mm in standard length; taken in 366 fathoms north of Glover Reef, British Honduras; April 20, 1925; S. Y. *Pawnee*. Paratype of *Grammicolepis squamilineatus* Mowbray.

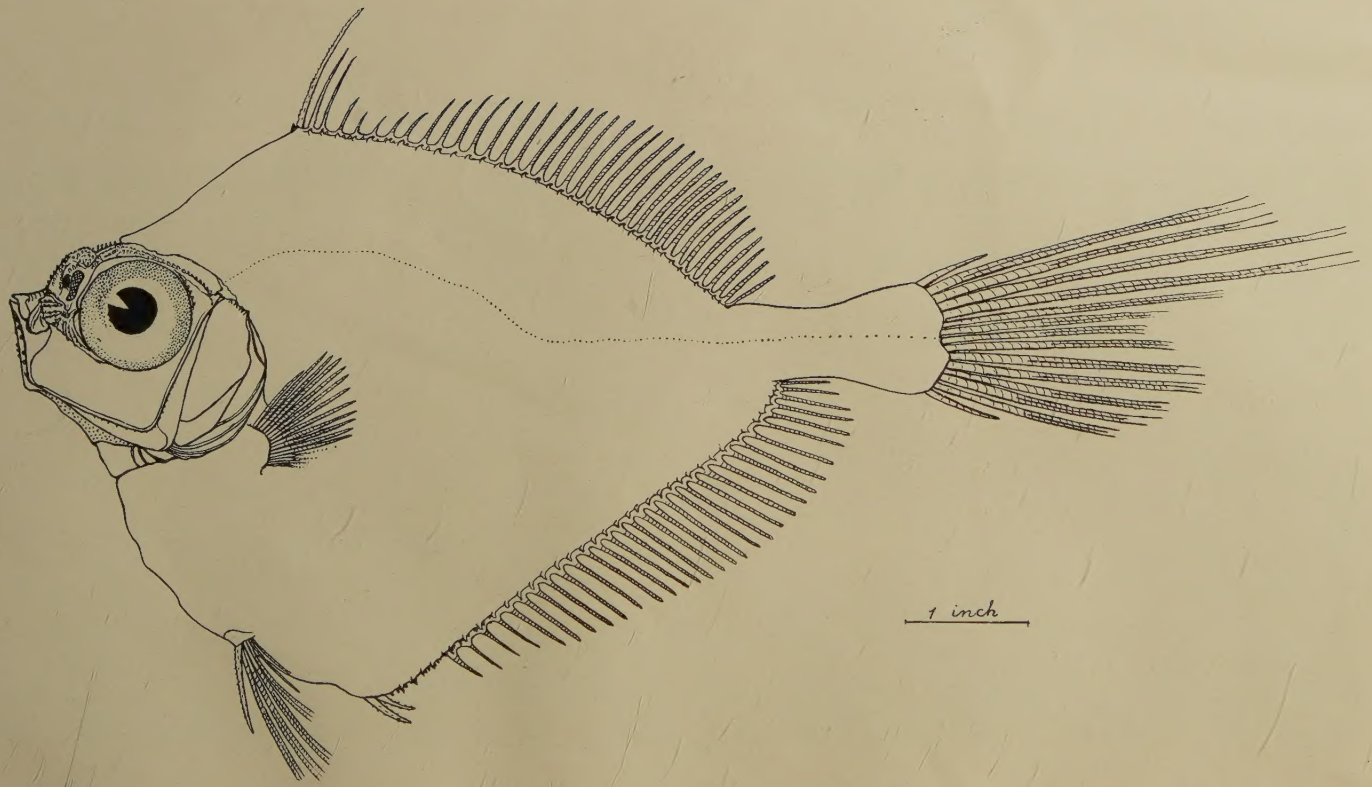
B. O. C. no. 518a, a specimen 73 mm in standard length; taken in 484 fathoms north of Glover Reef, British Honduras; April 20, 1925; S. Y. *Pawnee*. Paratype of *Grammicolepis squamilineatus* Mowbray.

Dorsal fin with a tiny, scarcely evident first spine; a main serrated spine; a thinner serrated spine; 3 or 4 soft, unarticulated spines; and 28 to 35 articulated rays. Anal with 2 short, serrated spines, the first longer; and 28 to 36 articulated rays. Pectorals 14 to 16. Color plain silvery, with indications of irregular dark blotches on the back.

Several important and extremely interesting changes in external anatomical features appear to take place in this species during growth.



A, *Grammicolepis brachiusculus* Poey, half-grown example, B.O.C. no. 518a; B, *Xenolepidichthys dalgleishi* Gilchrist, subadult example, B.O.C. no. 518b. Both specimens are paratypes of *Grammicolepis squamilineatus* Mowbray.



Grammicolepis brachiusculus Poey, subadult example, U.S.N.M. no. 102129. The scaly gular membrane has been stippled in the drawing. The figure errs in showing only 32 (instead of 34) articulated anal rays.

The high, acute angle of the lateral line, which is like that of *Xenolepidichthys* in the half-grown, becomes less acute in larger specimens and finally reaches an irregular low curve in the adult. Doubtless this is correlated with the considerable decrease of relative body depth with age. In most fishes the relative positions of the fin bases do not change greatly after the larval stage is passed, and characters relating to these positions are among the best and most stable of the external features used in classification. In *Grammicolepis*, however, I have been forced to the conclusion that the end of the dorsal base moves anteriorly with age, concomitant with a general pushing forward and downward of the upper part of the general bony framework of the fish. This apparently results in the head of larger specimens appearing as if it had been pushed upward (from the front) upon the axis of the body and gives the adult *Grammicolepis* a characteristic physiognomy very different from that of *Xenolepidichthys*, in which the head is much less prominent and less elevated in front.

The observation of these growth changes would not have been possible had I not been able to compare the small specimens in the Bingham Oceanographic Collection with the two larger specimens in the National Museum.

Counts of fin rays, etc.—These are given in the order in which the specimens are listed above. Dorsal III, III, 35; III, IV, 32; III, III, 29; III, III, 30; III, III, 28. Anal II, 36; II, 34; II, 29; II, 28; II, 28. Pectoral 15–15; 16–15; 14–14; 13–14; 14–14. Dorsal bucklers 34; 33; 29; 30; 30. Anal bucklers 35; 34; 27; 27; 27.

Measurements in millimeters.—These are given in the same order, the figures for the dried type of *Vesposus* being approximate only. Standard length 230; 182; 82; 85; 73. Depth 135; 115; 60; 65; 58. Head length 67; 49; 28; 29; 24. Bony orbit diameter 27; 23; 12; 14; 12. Snout length 21; 13; 8; 8; 7. Snout tip to dorsal origin 93; 67; 36; 39; 33. Dorsal base 145; 95; 42; 45; 40. Anal base 140; 104; 45; 48; 42.

Remarks.—Poey described and figured this species from a fresh 470 mm specimen, apparently not in very good condition, brought to the Habana market in April 1872. The type was skeletonized by Poey, and the skeleton was sent to Prof. Theodore Gill in Washington for the Smithsonian collection. A few years later Gill turned over the skeleton, which appears to have been incomplete, to Dr. R. W. Shufeldt for osteological study. Shufeldt's paper appeared in 1888, but I can find no trace of the specimen subsequent to that date. It may be that it is still in the private osteological collection of the late Dr. Shufeldt, to which I have not been able to obtain access.

In his paper on *Grammicolepis*, Shufeldt gave a complete translation of the text of Poey's paper, together with a figure of the whole fish. This figure, which was copied by Goode and Bean, was taken

largely from Poey's outline drawing but with some changes as well as the addition of the squamation.

Jordan's nominal *Vesposus* and Gilchrist's *Xenolepidichthys* were both differentiated from *Grammicolepis* by the presence of a row of strong, spiny bucklers along each side of the dorsal and anal bases, on the assumption that Poey's specimen lacked such structures. On reviewing the matter it is evident that both Jordan and Gilchrist depended entirely on Shufeldt's paper (or on Goode and Bean's partial copy of it) and that Shufeldt misinterpreted, and erroneously translated, one important sentence in Poey's account.

In the course of his description of the scales, Poey says, "La primera, tanto arriba como abajo, es más corta y lleva en la cabeza dos puntes endurecidas que accompañan la base de los radios." In connection with the context of the paragraph as a whole, I translate this as follows: "The first [scale], both above [=dorsally] and below [=ventrally], is shorter [than those toward the middle of the body] and carries at the head [end] two strong points which accompany the base of the rays." These strong points, or spines, and perhaps the fins themselves, were evidently not present on the skeleton when Shufeldt received it, and, being unable to understand what Poey meant, he translated the sentence as, "The leading scales on the body, above as well as below, are shorter and when carried on to the head, are doubly as firm as those found at the base of the fin rays." Knowing that all other grammicolepids have these spines, one can easily see what Poey was attempting to describe.

Moreover, Poey's outline drawing, which did not show the rays of the soft dorsal and anal, clearly figures the row of spines along the base of both dorsal and anal. Shufeldt took these spines for indications of the bases of the fin rays, and they do not appear in his figure, in which the rays are drawn in.

The only other point that might cause confusion is Poey's statement that *two* points are present. From my description above it is clear that at least the anterior spine-bearing bucklers at the fin bases show one or more subsidiary spines.

It is possible that the differences in meristic characters between the type of *Vesposus* and the smaller specimens from the Caribbean may have some significance. With my present material I am unable to do more than call attention to the fact.

The figure of the type of *Vesposus egregius* given by Jordan and by Jordan and Jordan, drawn from the dried and twisted type, is incorrect in a number of details and entirely lacks the very characteristic physiognomy of *Grammicolepis*, which is apparent even in the dry specimen.

Poey's large type appears to represent the fully adult form of the species. No other examples as large as his have been found.

Genus XENOLEPIDICHTHYS Gilchrist

Xenolepidichthys Gilchrist, 1922, p. 73 (type by monotypy, *X. dalgleishi* Gilchrist).

Grammicolepis (in part) Mowbray, *in* Breder, 1927, p. 29.

The generic characters are given in the table above. Only one species is known, from deep water in the Caribbean Sea, off South Africa, and about the Philippines.

XENOLEPIDICHTHYS DALGLEISHI Gilchrist

Xenolepidichthys dalgleishi Gilchrist, 1922, p. 73, pl. 12, fig. 1 (*Pickle* stations 104, lat. 29°57′05″ S., long. 31°14′30″ E; 111, lat. 29°43′30″ S., long. 31°22′30″ E; 141, lat. 29°48′55″ S., long. 31°22′30″ E.).—Barnard, 1925, p. 371, pl. 16, fig. 1 (off Natal coast; Algoa Bay; off Saldanha Bay); von Bonde, 1928, p. 26 (*Pickle* station 779, about lat. 29°48′S., long. 31°25′E.); 1933, pp. 59, 60, 61 (*Africana* stations 238A, lat. 29°48′55″ S., long. 31°19′40″ E; 239A, lat. 29°50′06″ S., long. 31°21′00″ E; 240A, lat. 29°53′40″ S., long. 31°19′12″ E.).—J. L. B. Smith, 1935, p. 184, pl. 18, fig. A (Great Fish Point).—Fowler, 1935, p. 373 (Durban).

Grammicolepis squamilineatus (in part) Mowbray, *in* Breder, 1927, p. 30 (one paratype; deep water north of Glover Reef, British Honduras).

U.S.N.M. no. 98830 (field parchment tag 1743), a specimen 87 mm in standard length; station D. 5112, off Sombrero Island, southern Luzon, latitude 13°48′22″ N., longitude 120°47′25″ E.; January 17, 1908; 12-foot Tanner beamtrawl; 177 fathoms; U. S. S. *Albatross.*

U.S.N.M. no. 98831 (field parchment tag 1742), a specimen 71 mm in standard length; same data as no. 98830. Figured example.

U.S.N.M. no. 98832 (field parchment tag 1744), a specimen 90 mm in standard length; same data as no. 98830.

B.O.C. no. 518b, a specimen 82 mm in standard length; taken in 484 fathoms north of Glover Reef, British Honduras; April 20, 1925; S. Y. *Pawnee.* Paratype of *Grammicolepis squamilineatus* Mowbray.

Dorsal fin with a tiny, scarcely evident first spine; a main serrated spine, which is long and provided with a filamentous tip in the young; a thinner serrated spine; three soft, unarticulated spines; and 28 or 29 articulated rays. Anal with a long, serrated first spine, nearly as long as, or longer than the head, its tip filamentous in the young; a second shorter serrated spine; and 27 to 29 articulated soft rays. Pectorals with 14 rays. Color silvery, the younger specimens with round dark spots, placed irregularly.

This species differs decidedly from *Grammicolepis* in the lesser extent of the changes in proportions and other external features during growth. The younger specimens have filamentous tips to the second dorsal and first anal spines, which are lost with growth, and the relative length of the second dorsal spine decreases. The body is deeper in the young than in the adult, but even the latter retains a very deep form. The high, pointed arch of the lateral line and the

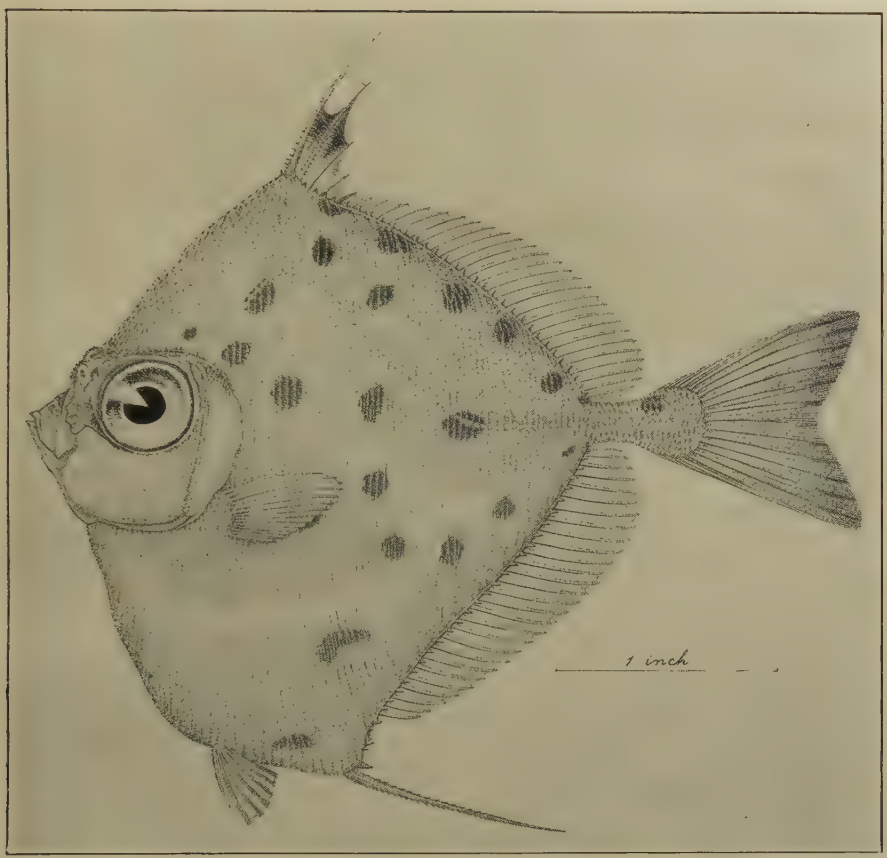
relative position of the ends of the dorsal and anal fins remain constant through life.

Counts of fin rays, etc.—These are given in the order in which the specimens are listed above. Dorsal III, III, 28; III, III, 29; III, III, 29; III, III, 28. Anal II, 27; II, 28; II, 29; II, 28. Pectoral 14–14; 14–14; 14–14; 14–14. Dorsal bucklers 29; 31; 30; 30. Anal bucklers 27; 27; 27; 27.

Measurements in millimeters.—These are given in the same order. Standard length 87; 71; 90; 82. Depth 78; 68; 80; 68. Head length 26; 22; 29; 26. Bony orbit diameter 13; 11; 14; 13. Snout length 8; 6; 9; 8. Snout tip to dorsal origin 47; 38; 48; 43. Dorsal base 51; 43; 52; 44. Anal base 54; 46; 56; 49.

Remarks.—This peculiar, deep-bodied fish has been known heretofore only from off South Africa, whence it was described by Gilchrist in 1922. The three Philippine examples recorded here were obtained by the *Albatross* many years before *Xenolepidichthys* was discovered in South Africa. The figure of one of these specimens, here reproduced as plate 7, was made by K. Ito on board the *Albatross* during the cruise on which the fishes were captured.

There is no doubt whatsoever of the identity of one of Mowbray's paratypes of *Grammicolepis squamilineatus* with this species. The fact that this specimen was not distinguished by Mowbray from his other examples, which are plainly *Grammicolepis*, is evidence of the remarkable similarity of the young of the latter genus to *Xenolepidichthys*.



Xenolepidichthys dalgleishi Gilchrist, subadult example, U.S.N.M. no. 98831. The figure errs in showing 28 (instead of 29) articulated rays, and the upper border of the head, above the eye, is too strictly horizontal. Drawn by K. Ito.

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